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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

JUN 16 1981

Docket No. 50-336



Mr. W. G. Counsil, Vice President
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Dear Mr. Counsil:

As a result of our review of the January 2, 1981 Loss of DC Power Event at Millstone Nuclear Power Station, Unit No. 2, we request that you review Enclosure 1 and 2, "Sequence of Events" and "Analysis and Concerns", respectively and provide any comments you might have. In addition, we request that you provide the specific additional information noted in Enclosure 3.

Please provide your response to the three enclosures within 90 days of receipt of this letter.

Sincerely,

Robert A. Clark, Chief
Operating Reactors Branch #3
Division of Licensing

Enclosures:
As stated

cc: See next page



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# LOSS OF DC BUS AT MILLSTONE 2

## SEQUENCE OF EVENTS

The Millstone 2 design consists of two redundant and independent emergency power systems. These will be referred hereinafter as the A and B systems. The enclosed Figure 1 depicts a simplified single line arrangement of the ac and dc redundant emergency power systems and will be used to support the description of the following sequence of events.

Initial Conditions

The reactor was operating at 100% power.

Initiating Event - Time Zero

- The main 125 volts dc emergency bus in system A was deenergized when the main feeder breaker connecting the battery and its charger outputs to this bus was inadvertently opened by the plant equipment operator.
- The deenergization of this bus resulted in the removal of control power to the reactor trip breakers causing a reactor scram.
- The turbine trip, which normally follows a reactor trip did not occur.
- System A diesel generator started.

Time Approximately 30 Seconds

- Turbine was manually tripped.
- The fast transferring of the in-house loads from the normal station service transformer (NSST) to the reserve station service transformer (RSST) which normally follows a turbine trip did not occur because the transfer logic is powered from the dc system A.

- The failure of the fast transfer left open the two breakers through which offsite power is fed to the 4.16 Kv ac emergency bus in system B. This resulted in the loss of offsite power to system B.
- The loss of offsite power to the 4.16 Kv emergency bus in system B resulted in the starting of system B diesel generator.
- The two breakers through which offsite power is fed to the 4.16 Kv emergency bus in system A did not operate because dc control power was not available. Thus, offsite power remained available to system A.
- The automatic opening of the main generator switchyard breakers which normally follows a turbine trip did not occur because the initiating signal to open the breakers could not be generated as a result of the loss of dc system A. Thus, the main generator started to motor.
- One of the two 6.9 Kv buses which provide power to two of the reactor coolant pumps was deenergized when the fast transfer to the reserve transformer could not be accomplished. The other 6.9 Kv bus remained connected to the main generator through the normal transformer.

Time Approximately 50 Seconds

- The 125 volts dc emergency bus in system A was energized when the main feeder breaker was closed.
- With dc control available, the source of power to the 4.16 Kv emergency bus and to the 6.9 Kv bus in system A was transferred from the normal to the reserve transformer.

- The 6.9 Kv bus in system B was connected to the reserve transformer. This connection was immediately lost due to an overcurrent condition caused by attempting to start all the loads in the bus at the same time. This may have occurred because the design did not include the feature to disconnect the loads from the bus during a zero voltage condition.
- The supply breaker from the reserve transformer to the 4.16 Kv emergency bus in system B could not be closed because the breaker was locked-out when the offsite was previously lost.
- The generator output breakers in the switchyard were opened and thus, the main generator was removed from the 345 Kv switchyard.
- System A diesel generator shut down automatically as a result of a design feature which is activated to trip the diesel generator when dc control power is restored.
- Upon restoration of dc to system A, the main steam isolation valves closed thereby tripping the main feedwater pumps. The electrical auxiliary feedwater pumps were started and water was supplied to both steam generators.

Time 10 Minutes

- System B diesel generator tripped automatically as a result of a water leak which sprayed the electronic governor and caused the trip of the diesel generator set. Thus, the 4.16 Kv emergency bus was deenergized.
- The load shed signal was overridden and the 4.16 Kv emergency bus in system B was reenergized from the reserve transformer.
- Several instruments supplied from a non-vital instrument panel in system B were not available as a result of blown fuses.

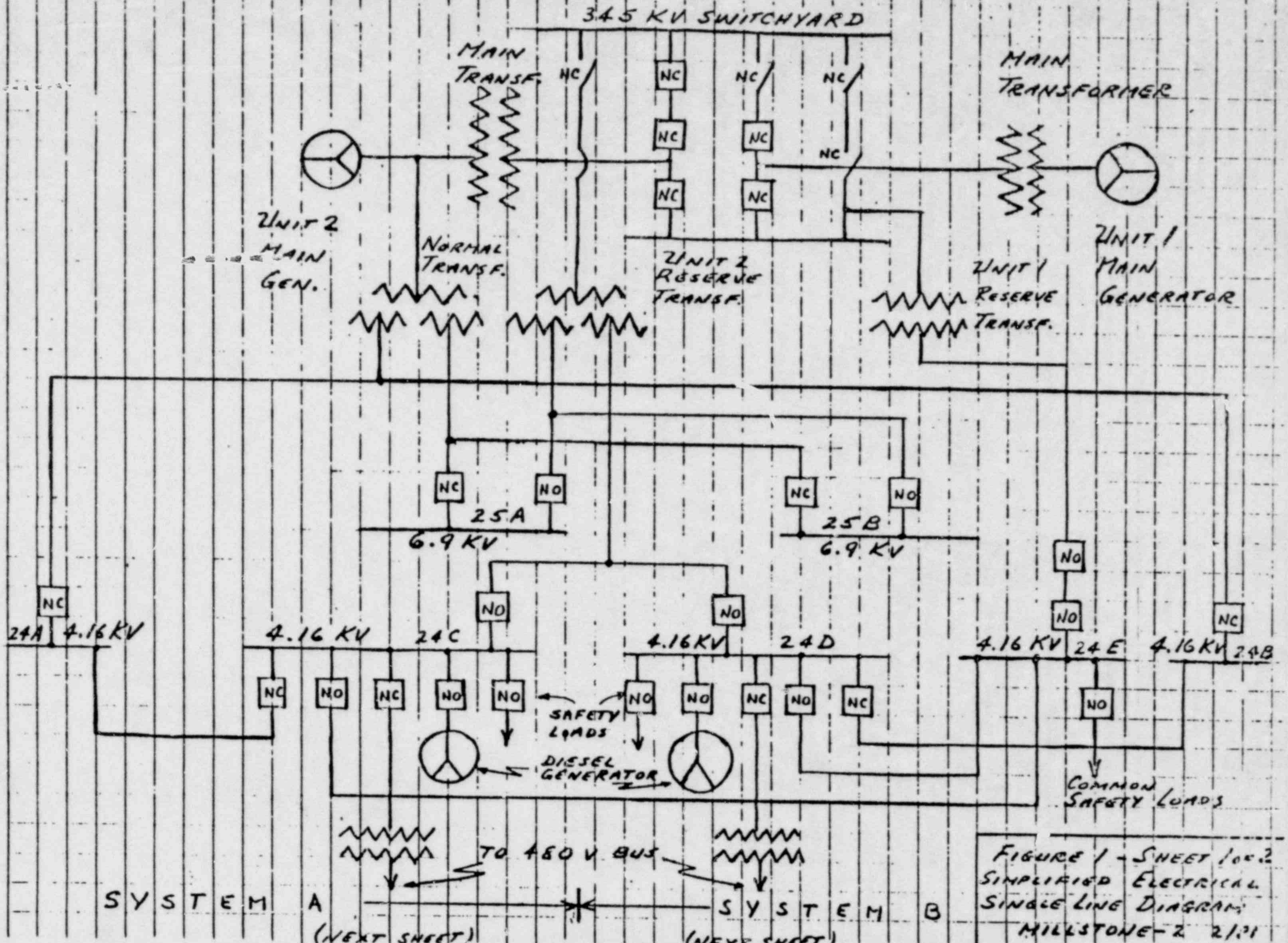


FIGURE 1 - SHEET 1 OF 2
SIMPLIFIED ELECTRICAL
SINGLE LINE DIAGRAM
MILLSTONE-2 2/81

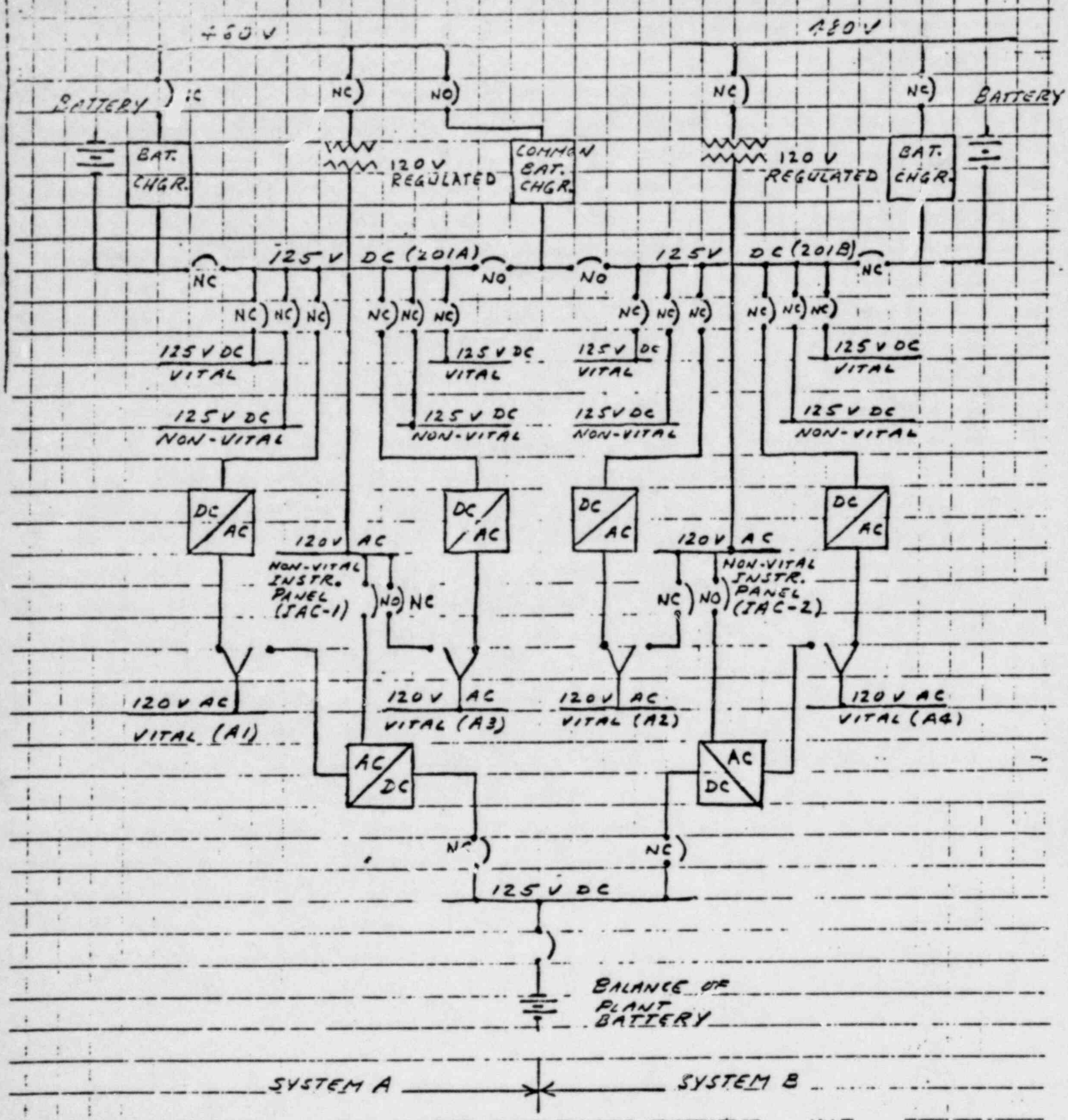


FIGURE 1 - SHEET 2 OF 2
SIMPLIFIED ELECTRICAL
SINGLE LINE DIAGRAM
MILLSTONE - 2 2/81

ENCLOSURE 2

# LOSS OF DC BUS AT MILLSTONE 2

## ANALYSIS AND CONCERNS

Our analyses, findings and conclusions of this operating reactor event were based only on the information listed in the reference section of this enclosure. The following discussion identifies those items of concern.

### Station Blackout

The sequence of events showed that prior to restoration of dc power to system A, offsite power has been lost to system B and remained connected to system A. In addition, the emergency diesel generators had started and the B diesel generator was supplying its emergency bus. The A diesel generator came up to speed and assumed the mode of standby because system A was being supplied by offsite power. In the event that offsite power would not have been available to system A, it would have been impossible to connect the diesel generator to the emergency bus in system A automatically because of the lack of dc control power. The restoration of dc power to system A resulted in the energization of a shutdown relay in the control and circuits of the diesel generator of system A which caused the shutdown of the diesel. Ten minutes since the occurence of the initiating event, System B diesel generator was automatically shutdown as a result of a water leak which sprayed the electronic governor. Immediately after the trip of system B diesel generator, the only remaining source of ac power to the emergency buses was the offsite power supply to system A.

It appears from the information available for review that if the operator had waited 10 more seconds to restore dc power to system A, it would have resulted in the automatic loss of the offsite power connection to system A.

Thus, the total loss of ac (station blackout) would have occurred immediately after system ' diesel generator automatically tripped. Offsite power to system ~ would have been interrupted when the reverse power relay time delay have elapsed 30 seconds after the main generator started to motor (which was approximately 30 seconds after the occurrence of the initiating event) and have caused the separation of the main generator from the switchyard. Under the same set of circumstances a station blackout would have also occurred if dc power would have been lost to system B. It should be noted that the capability to remotely control the removal of decay heat from the control room would be totally lost if the steam driven auxillary feedwater pump dc power requirements were being satisfied from the failed dc system. However, this control of the steam driven auxiliary feedwater flow can be accomplished remotely. It should also be noted that the design includes the manual capability to restore ac and dc power to the emergency buses under these circumstances.

This event also illustrates the possibility of a single event in one of the two redundant portions of the dc power system leading to the trip of the plant and causing loss of the ac emergency power supply associated with the portion of the failed dc power system and the total loss of offsite power. It appears that such a design is inconsistent with satisfying the requirements set forth in General Design Criterion 17 of Appendix A to 10 CFR Part 50 with regard to including provisions in the design "to minimize the probability of losing electric power from any of the remaining supplies as a result of, or coincident with, the loss of power generated by the nuclear power unit, the loss of power from the transmission network, or the loss of power from the onsite (emergency) power supplies".

System A Diesel Generator Trip

It appeared that the A diesel generator started when dc emergency power to system A was lost. The loss of dc control power caused the air start valves to open allowing compressed air to start the diesel generator. Although the diesel generator was running, it was not automatically connected to the emergency bus because system A was being supplied by offsite power. If offsite power had not been available, it would have been impossible to close the diesel generator output breaker because of the lack of dc control power. However, the output breaker can be manually closed at its motor control cabinet and then as the need arises during an emergency condition, the loads could be manually connected to the diesel generator.

The restoration of dc power to system A caused the energization of a shutdown relay in the control circuits of the diesel generator of system A which resulted in the shutdown of the diesel.

The system design to start the diesel generator automatically as a result of losing dc emergency power in the same system has merits in view of the fact that as a consequence of losing dc power, offsite power is also lost to the emergency buses. The connection of the diesel generator to the emergency bus and the subsequent energization of the loads can be accomplished manually if the need arises during an emergency condition. It should be recognized that there are mechanical limitations that restrict the amount of time that a diesel generator can be operated unloaded. Also, without dc power available, there is no protection to the system in the event of electrical fault. Thus, the importance of the emergency situation must be promptly assessed and action taken to either load or trip the diesel generator.

In view of the fact (1) that offsite power could be totally lost to the emergency buses as a result of losing dc emergency power and (2) of the unreliability associated with the starting of diesel generators, it is important to safety to keep the diesel generators running in anticipation that this power source will be required. This will circumvent the high probability of failure during the starting of the diesel generators in case they are subsequently needed. It could also lessen the burden of the operator during the initial critical recovering steps for this type of event. In addition, the feature of the control circuit design that upon restroation of dc power shuts down the diesel generator is inconsistent with Branch Technical Position ICSB (PSB) 17 of the Standard Review Plan. The Position requires that protective trips such as this one should not interfere with the successful functioning of the diesel generators during accident conditions.

Load Shedding Feature Reinstatement

The sequence of events has shown that the design does not have the capability of undervoltage load shed at the 6.9 Kv bus level. After the 6.9 Kv bus in system B was deenergized for 20 seconds, it was connected to the reserve transformer upon restoration of dc power. This connection was immediately lost due to an overcurrent condition caused by attempting to start all the loads in the bus at the same time. These loads were not disconnected when the 6.9 Kv bus was first deenergized. Although it may appear that the lack of this capability of undervoltage load shed at the 6.9 Kv level may have no safety significance, it is not a desirable design practice.

The reason to bring up this problem of apparently no safety significance is to relate it to a similar situation which may have occurred when the diesel generator in system B tripped. The sequence of events indicated that after system B diesel generator tripped, the load shed signal was overridden and the 4.16 Kv emergency bus in system B was reenergized from the reserve transformer. It is inferred from this statement that the design may suffer from the same lack of undervoltage load shed capability as that at the 6.9 Kv bus level. The automatic reinstatement of the undervoltage load shed feature has been a NRC requirement since 1976 for emergency diesel generator systems. Also, the possibility exists that during this event the undervoltage load shed feature may have not functioned as designed.

The requirement to automatically reinstate the load shedding feature when the emergency source supply breakers are tripped from the corresponding emergency buses arose as a result of a sustained low grid voltage condition which was experienced on July 5, 1976 at Millstone 2. A safety evaluation was prepared following the grid degradation event of

July 5, 1976 and reflected that the reinstatement of load shedding was a feature of the Millstone 2 design for emergency diesel generators.

Instrumentation Blown Fuses

Ten minutes after the initiating event occurred, system B diesel generator experienced a malfunction caused by a water leak which sprayed the speed controller. This resulted in an underspeed condition followed by a low oil pressure trip of the diesel generator. The low oil pressure trip corresponded to an electrical frequency of approximately 45 hertz. At approximately the same time, several fuses were blown in the instrumentation loops being powered from a 120 V ac non-vital instrument panel associated with system B. This panel has been identified in the enclosed Figure 1 as IAC-2.

The instrumentation loops received power from a regulated 480/120 V transformer which experienced a frequency of 45 hertz during the underspeed condition of system B diesel generator. Since the instrumentation loops consist of inductive loads and have a transformer input, a decrease in power supply frequency will cause the transformer inductive reactance to decrease and input current to increase and if this continues the transformers will reach saturation causing a rapid increase in input current. NNECO attributed this overcurrent condition as the reason for the blown fuses in the instrumentation loops. The licensee has conducted a test that simulated frequency decay to 50 Hz in a typical instrumentation loop power supply. Extrapolating the data to below 50 Hz indicated that the low frequency caused the fuses to blow. A review of the licensee's information in this regard was found acceptable.

It should be noted that the instrumentation loops associated with this non-vital bus are considered non-safety related and their failure should be of no consequences to safety. There are other instrumentation loops in system B being supplied from 120 V ac vital buses which are considered safety related and their failure or degradation as a result of this underfrequency event could have serious safety consequences.

Electrical Independence at the 120 V AC Level

As a result of evaluating the effects of this event, it was noted that the independence between the two redundant electrical systems could possibly be compromised at the 120 V ac level. As shown in the enclosed Figure 1, each system has two vital 120 V ac buses and one non-vital bus. One vital bus of each system is fed automatically, upon loss of the normal source, from a dc/ac inverter for which the source of dc is the balance of the plant battery (referred as the turbine battery). The other vital bus of each system is fed automatically from the non-vital bus upon the loss of the normal supply. Each non-vital bus can also be supplied from the same dc/ac inverter connected to the balance of the plant battery and used as mentioned before as an automatic alternate source for one of the vital buses. Thus, the design provisions to assure continuity of power to the vital buses from the common balance of the plant battery could also result in the compromising of the required independence between redundant electrical systems.

It is our concern that a single event affecting the non-safety related balance of the plant battery could degrade the battery and/or its associated equipment to a point that could affect the operability of sufficient vital buses in both systems resulting in the loss of protective function when required.

Actuation Power Source to the Main Steam Line Isolation Valves

The sequence of events indicated that the main steam line isolation valves closed upon restoration of dc power to system A. There are two main steam lines each provided with an isolation valve. These two main steam isolation valves should be mechanically and electrically independent of each other. However, the loss of one of the two redundant dc systems and subsequent restoration of it have caused the closure of both supposedly electrically independent main steam line isolation valves. It is our concern that a single failure in the power connections to these valves may result in the loss of capability to perform their intended safety function during a steam line break accident or to maintain at least one of the two steam generators as a heat sink to remove reactor decay and sensible heat.

References

1. Report on the Reactor Trip of Unit 2 on January 2, 1981 dated January 20, 1981. Prepared by Northeast Utilities.

2. Preliminary Notification of Event -- PNO-I-81-01, January 2, 1981. Subject, Loss of 125 Volt Vital D.C. Bus and Reactor Trip. Facility, Millstone Unit 2.

3. Report on the Sequence of Events, January 2, 1981. Reactor Trip of Millstone Nuclear Power Station.

4. Draft Evaluation of Electrical Problems Associated with the Millstone 2 Events of January 2, 1981 and January 6, 1981. Prepared by the Chemical, Electrical and Instrumentation Section, Division of Resident and Regional Reactor Inspection, Office of Inspection and Enforcement.

5. Chapter 8.0 of the FSAR for Millstone Unit 2.

## LOSS OF D.C. BUS AT MILLSTONE 2

## REQUEST FOR ADDITIONAL INFORMATION

1. Provide the results of an analysis that demonstrates the capability of the design against the requirements of GDC 17 as discussed in Enclosure 2. This analysis can be made part of the long term corrective action that NNECO proposed regarding this event, as documented in a letter dated January 20, 1981.

2. Insufficient information is available to determine whether the dc power feed to the close and trip circuits associated with the breakers through which offsite power is supplied to the emergency buses are independent. It is our concern that a single failure in the dc power feed to these breakers may result in the loss of capability to open the breakers when required and thus, prevent the emergency power supplies from being connected to these buses. This will result in a station blackout. Verify that this is not the case and provide the results of such a verification.

3. Examine the design of the diesel generators and either demonstrate that tripping a running generator during abnormal and accident conditions is acceptable upon restoration of dc power or modify the present design to prevent this occurrence from happening. The design modifications must satisfy the positions set forth in BTP ICSB (PSB) 17.

4. Confirm that the Millstone 2 design includes the capability for the automatic reinstatement of the undervoltage load shedding feature at the 4.16 Kv emergency bus level. Submit a typical electrical elemenetary diagram that depicts the undervoltage load shedding feature inclusion in the control circuits of a 4.16 Kv safety related load.

5. If the automatic reinstatement of the load shedding feature is included in the design, explain why the load shed signal associated with system B diesel generator was overridden as indicated in the sequence of events prepared by NNECO.

6. State whether any safety loads were automatically sequenced to system B diesel generator. Identify these loads, if any.

7. Explain the reasons why no evaluation or test was performed to demonstrate that the capability of the safety related instrumentation loops connected to the vital 120 V ac buses and associated battery chargers and inverters in system B have not been degraded below an unacceptable level as a result of this underfrequency event, even though blown fuses were not found.

8. Examine the design and recommend modifications (including Technical Specification changes) that will preclude supplying either manually or automatically vital buses in supposedly independent systems from a single non-safety related balance of the plant battery at the same time.

9. Review the design and verify whether the electrical and air aspects of it for each main steam line isolation valve are independent from those associated with its redundant counterpart. If they are not, the licensee must either demonstrate that the safety consequences of an electrical or air related failure disabling both valves are acceptable, or modify the design accordingly. Support the justification of the design with a simplified functional diagram showing the electrical and air interfaces for the main steam line isolation valves.